AD-A259 312

# REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: unclassified

1b. RESTRICTIVE MARKINGS: unclassified

2a. SECURITY CLASSIFICATION AUTHORITY: unclassified

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE: unclassified

3. DISTRIBUTION / AVAILABILITY OF REPORT: This document has been approved for public release and sale; its distribution is unlimited.

4. PERFORMING ORGANIZATION REPORT NUMBER(S): N00014-89-J-1281

5. MONITORING ORGANIZATION REPORT NUMBER(S): N00014-89-J-1281

6a. NAME OF PERFORMING ORGANIZATION: UW-Madison

6b. OFFICE SYMBOL *(If applicable)*

7a. NAME OF MONITORING ORGANIZATION: Office of the Chief of Naval Research

6c. ADDRESS *(City, State, and ZIP Code)*
750 University Avenue
Madison, Wisconsin 53706

7b. ADDRESS *(City, State, and ZIP Code)*
800 N. Quincy St., Code 1511:EAA
Arlington, Virginia 22217-5000

8a. NAME OF FUNDING / SPONSORING ORGANIZATION: ONR

8b. OFFICE SYMBOL *(If applicable)*

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS *(City, State, and ZIP Code)*
800 N. Quincy St., Code 1511:EAA
Arlington, Virginia 22217-5000

10. SOURCE OF FUNDING NUMBERS

| PROGRAM ELEMENT NO. | PROJECT NO. | TASK NO | WORK UNIT ACCESSION NO. |
|---|---|---|---|
| | | | |

11. TITLE *(Include Security Classification)*: Central Factors in the Classification of Transient Acoustic Signals

12. PERSONAL AUTHOR(S): Robert A. Lutfi

13a. TYPE OF REPORT: unclassified

13b. TIME COVERED: FROM 3/1/89 TO 4/30/92

14. DATE OF REPORT *(Year, Month, Day)*: 92/12/10

15. PAGE COUNT: 3

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

| FIELD | GROUP | SUB-GROUP |
|---|---|---|
| | | |
| | | |

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

see attached



20. DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☒ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION

22a. NAME OF RESPONSIBLE INDIVIDUAL

22b. TELEPHONE *(Include Area Code)*

22c. OFFICE SYMBOL

## Final Progress Report

**Grant Number:** N00014-89-J-1281
**Title:** Central Factors in the Classification of Acoustic Transients
**PI:** Robert A. Lutfi
**Period:** 3/1/89 through 9/30/92

**The Proportion-of-Total-Variance Rule for the Discrimination of Auditory Patterns.**

Random variation is an unavoidable feature of real-world sound. The ability to make sense of our acoustic environment depends on how we resolve the uncertainty associated with rapid, unpredictable changes in the natural signals we encounter. It is noteworthy therefore that psychoacoustic studies consistently reveal profound detrimental effects of signal uncertainty on our ability to make even the most simple auditory discriminations. We can detect a few Hz change in the frequency of a tone when there is no uncertainty regarding the signal (Wier, Jesteadt, and Green, 1977), but if this signal is embedded in a sequence of tones with frequencies that vary randomly from trial to trial, as much as a 1000-Hz change in the signal may go unnoticed, even after weeks of training (Watson, 1981). Signal uncertainty has equally adverse effects on the detection of changes in the intensity and duration of signals. Here too the size of the just-detectable change seems far too large to accommodate the informational demands of real-world listening. How are these results to be reconciled?

After decades of research, investigators have been unable to provide a satistactory answer to this question - that is, until very recently. In a paper submitted last month to the Journal of the Acoustical Society of America (enclosed), we describe what appears to be a general rule of auditory perception that governs the discrimination and classification of unfamiliar auditory patterns. The general rule may be stated as follows: each component of a random auditory pattern is resolved with an accuracy that is a function of its *proportion of the total variance* (PTV) in the pattern. We show that the PTV rule can account for nearly all of the major results of studies conducted over the last two decades on the discrimination of unfamiliar auditory patterns. Here, the often profound and sometimes counterintuitive effects of pattern uncertainty are given a simple explanation - they reflect a general property of auditory analysis wherein the perception of an auditory pattern, regardless of its defining attributes, is dominated by it's most variable features.

The discovery of the PTV rule was actually the outgrowth some work of Kidd and Watson (in press) and an earlier publication supported by ONR (Lutfi, 1992b). Our approach in the latter paper was to garner understanding through a theoretical analysis of ideal observers. When attempting to understand the processes underlying human performance in discrimination and classification tasks it is often helpful to consider what an intelligent observer would do in the same task. In the present application, this amounted to identifying decision rules that maximize percent correct in these tasks. We considered one such rule in which the observer reports a difference between patterns whenever the weighted sum of the tone values in the pattern exceeds a criterion. The weights in this case are determined by the likelihood of a change occurring on each component. We showed that this rule leads to the prediction that performance will be related to the target's proportion of total variance in the pattern, the exact form of the function being determined by the weights listeners actually use in these tasks. In the recently submitted paper, this analysis is carried one step further by making a specific assumption regarding these weights. It is assumed that the weights are determined by a continuous and rectangular time-window applied over the entire duration of each pattern. This assumption was made with the intent of simplifying the analysis, but the result is a PTV rule that accounts for the effect of most of the major variables in tasks involving the discrimination of unfamiliar tone patterns. These include, the total number of tones in the pattern; the total duration of the pattern; the target's position in the pattern; the relative durations of target and context tones; the relative variances of the target and context tones; the number of targets; the manner of presentation of the tones, sequential or simultaneous; the type of discrimination task, intensity discrimination versus frequency discrimination; and the type of psychophysical procedure, method of adjustment versus same-different. A summary of the predictions of the PTV rule for the data of some of these studies is shown in Fig 1.

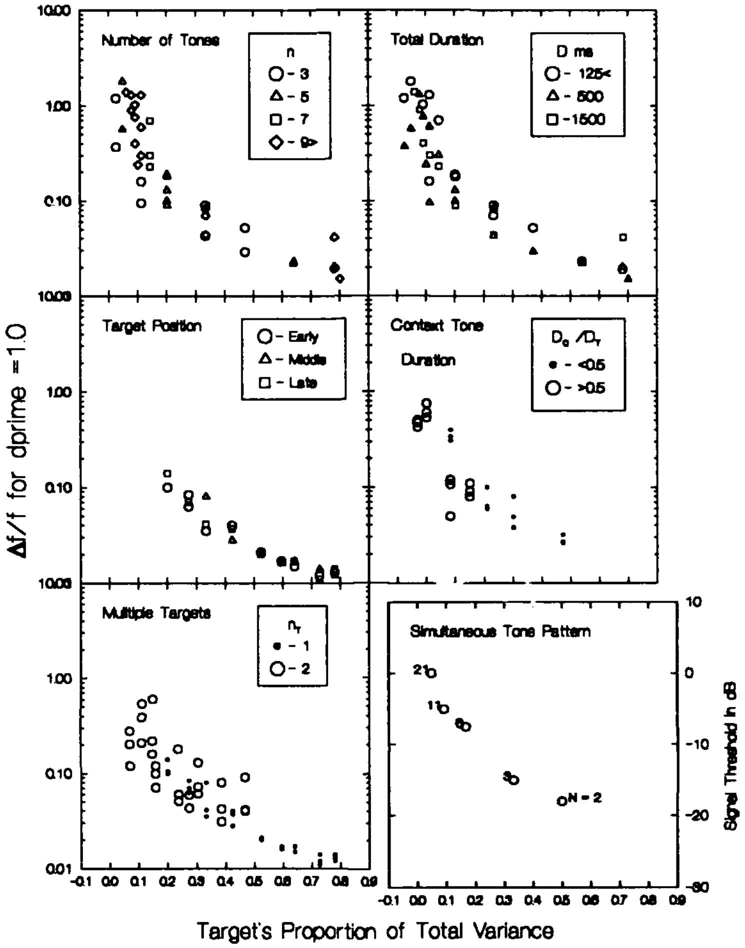




FIG. 1: Reading from left to right and top to bottom: Panel 1. Data from Watson, Kelly, and Wroton (1976), Watson, Foyle, and Kidd (1990), and Exp. 1 of Kidd and Watson (1992). The listener's task is to detect a change in the frequency of a target tone embedded in a sequence of tones with frequencies that vary randomly from trial to trial. The data are ∂f/f values (average of four to seven listeners) required for a performance level of d'=1.0 in the same-different procedure. Panel 2. Same data plotted with total sequence duration as parameter. Panel 3. Data from Exp. 2 of Kidd and Watson (1992) where parameter is the position of the target in the sequence. Panel 4. Data of Exp. 3 of this study where the parameter is the relative duration of a single context tone. Panel 5. Data from Exp. 4 of this study in which the sequence included nonadjacent multiple targets. Panel 6. Data from Spiegel, Picardi, and Green (1981) in which all tones in the pattern are played simultaneously and the listener's task is to detect an increment in the level of a single component (All data replotted with permission).

The PTV rule may represent the most significant advance in our understanding of the discrimination and classification of variable acoustic patterns since the classic studies of Watson and his colleagues first demonstrated the profound effects stimulus uncertainty can have on auditory pattern discrimination performance. If applied properly this discovery could substantially aid in the efficiency of personnel selection strategies for identifying exceptional sonar-signal classifiers.

**Papers published in refereed journals.**

(1) Lutfi, R.A. (1989). Informational processing of complex sound: I. Intensity discrimination. Journal of the Acoustical Society of America. 934-944.
(2) Lutfi, R.A. (1990a). Informational processing of complex sound: II. Cross-dimensional analysis. Journal of the Acoustical Society of America, 87, 2141-2148.
(3) Lutfi, R.A. (1990b). How much masking is informational masking?, Journal of the Acoustical Society of America, 88, 2607-2610.
(4) Lutfi, R.A. (1992a). Comment on "Analysis of weights in multiple observation tasks" [J. Acoust. Soc. Am. 86, 1743-1746 (1989)]. Journal of the Acoustical Society of America 91, 507-508.
(5) Lutfi, R.A. (1992b). Informational processing of complex sound: III. Interference. Journal of the Acoustical Society of America, 91, 3391-3401.

**Abstracts published in refereed journals.**

(1) Lutfi, R. A. (1989). Informational processing across acoustic dimensions. Midwest Psychological Association, Chicago, IL.
(2) Lutfi, R.A. (1990c). An information-theoretic analysis of tone-in-noise masking, Journal of the Acoustical Society of America, 88, S179.
(3) Raman, I., and Lutfi, R.A. (1990). Interaction of context and target uncertainty in the discrimination of random tone-sequences, Journal of the Acoustical Society of America, 88, S179

**Invited presentations at Workshops or Prof. Society Meetings.**

(1) Lutfi, R. A. (1989a). Neural networks. Department of Psychology, University of Florida, Gainesville, Florida, USA.
(2) Lutfi, R. A. (1989b). Complex auditory pattern perception. Engineering Foundation Research Conference on Implantable Auditory Prostheses, Potosi, Missouri, USA.
(3) Lutfi, R. A. (1990). Human detection and discrimination of uncertain acoustic signals. Institute for the Study of Human Capabilities, Psychology Department, Indiana University, Bloomington, Indiana, USA.
(4) Lutfi, R.A. (1991a). The information in auditory patterns. Invited talk given at Boys Town National Institute, Omaha, Nebraska, U.S.A.
(5) Lutfi, R.A. (1991b). Uncertainty and structure in auditory pattern perception. Invited talk, Parmly Lecture Series, sponsored by the Parmly Hearing Institute. Loyola University of Chicago, Chicago, Illinois, U.S.A.

**Awards**

(1) Awarded remodelling request ($27,000) from Univerity of Wisconsin Letters and Science in support of federally funded projects. Money was used to convert unused space to a psychoacoustic research lab where ONR supported research is currently being conducted.
(2) Awarded Grant-in-Aid application ($12,000) by University of Wisconsin Graduate School for continuation of Deafness Research Foundation related research beyond 3 year limit.